One-Dimensional Kinematics Review

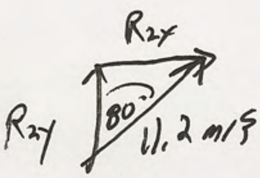
1) Draw the following to scale in the proper direction.
   a. Wind of 8.6 m/s from a course of 170°.
   b. 485 km at N15°E

SOH CAH TOA

2) Find 14.8 m/s N17°W + 11.2 m/s N80°E by: (R_1, R_2)
   a. Drawing a scale diagram
   b. Mathematically using components [17.4 m/s [N23°E]]

$\vec{R}_{1x} = 14.8\,m/s \sin 17°$
$\vec{R}_{1x} = -4.3271\,m/s$

$\vec{R}_{1y} = 14.8\,m/s \cos 17°$
$\vec{R}_{1y} = 14.1533\,m/s$



$\vec{R}_{2x} = 11.2\,m/s \sin 80°$
$\vec{R}_{2x} = 11.0298\,m/s$

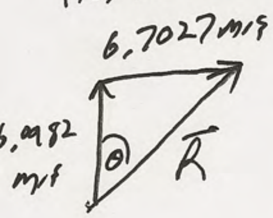
$\vec{R}_{2y} = 11.2\,m/s \cos 80°$
$\vec{R}_{2y} = 1.9449\,m/s$

WATCH YOUR SIGNS!!!

$\vec{R}_x = -4.3271\,m/s + 11.0298\,m/s = 6.7027\,m/s$

$\vec{R}_y = 14.1533\,m/s + 1.9449\,m/s = 16.0982\,m/s$

Resultant:



$R = \sqrt{(16.0982\,m/s)^2 + (6.7027\,m/s)^2}$

$R = 17.4378\,m/s$

$\theta = \arctan\left(\frac{6.7027\,m/s}{16.0982\,m/s}\right)$

$\theta = 22.605°$

$\vec{R} \approx 17.4\,m/s\,[N23°E]$

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3) Find 75 km [216°] – 26 km [252°] by:

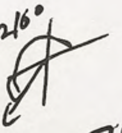
a. Drawing a scale diagram

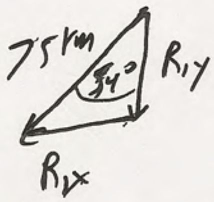
b. Mathematically using components. [56 km [200°]]

Rewrite by adding the opposite:

$75 Km [216°] + 26 Km [72°]$

$\vec{R}_1 \qquad \vec{R}_2$





$\vec{R}_{1x} = 75 Km \sin(54°)$

$\vec{R}_{1x} = -60.6763 Km$

$\vec{R}_{1y} = 75 Km \cos(54°)$

$\vec{R}_{1y} = -44.0839 Km$

$\vec{R}_{2x} = 26 Km \cos(72°)$

$\vec{R}_{2x} = 8.0344 Km$

$\vec{R}_{2y} = 26 Km \sin(72°)$

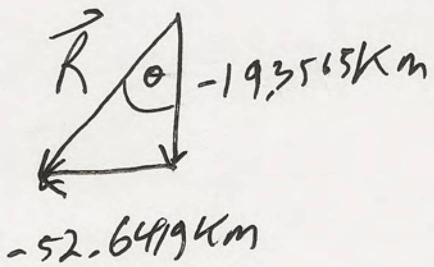
$\vec{R}_{2y} = 24.7275 Km$

$\vec{R}_x = -60.6763 Km + 8.0344 Km = -52.6419 Km$

$\vec{R}_y = -44.0839 Km + 24.7274 Km = -19.3565 Km$

Resultant:

$\vec{R} = \sqrt{(-52.6419 Km)^2 + (-19.3565 Km)^2}$



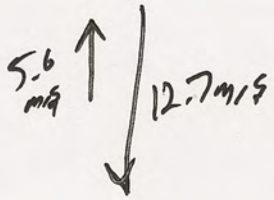
$\vec{R} = 56.0878 Km$

$\theta = \arctan\left(\frac{-52.6419 Km}{-19.3565 Km}\right)$

$\theta = 69.811°$

$\vec{R} \approx 56 Km [S 70° W]$

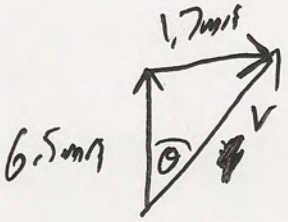
4) A person walks north at 5.6 m/s on a train while the train moves south at 12.7 m/s. Find the person's velocity relative to someone standing outside on the ground. [7.1 m/s [South]]



$5.6\,m/s + (-12.7\,m/s)$

$\vec{v} = -7.1\,m/s = 7.1\,m/s\,[S]$

5) A fisherman heads directly north across a river at 6.5 m/s while a current flowing to the east at 1.7 m/s acts upon the boat. What is the boat's actual velocity? [6.7 m/s N14.7°E]



$v = \sqrt{(6.5\,m/s)^2 + (1.7\,m/s)^2}$

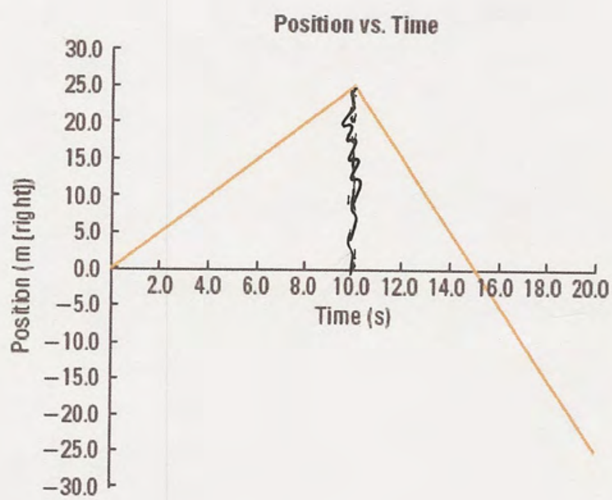
$v = 6.7186\,m/s$

$\theta = \arctan\left(\frac{1.7\,m/s}{6.5\,m/s}\right)$

$\theta = 14.6568\,m/s$

$\vec{v} = 6.7\,m/s\,[N14.7°E]$

6) Determine the average speed, average velocity, and net displacement from the position-time graph below. [3.75 m/s, -1.25 m/s [right], -25.0 m [right]]



$\Delta d = 75.0\,m$

$\Delta t = 20.0\,s$

$v = \frac{75.0\,m}{20.0\,s}$

$v = 3.75\,m/s$

$\vec{\Delta d} = -25.0\,m$

$\Delta t = 20.0\,s$

$\vec{v} = \frac{-25.0\,m}{20.0\,s}$

$\vec{v} = -1.25\,m/s$

7) A scuba diver swims at a constant speed of 0.77 m/s. How long will it take the diver to travel 150 m at this speed? [190 s]

$v = 0.77\ m/s$

$\Delta d = 150\ m$

$\Delta t = ?$

$v = \frac{\Delta d}{\Delta t}$

$\Delta t = \frac{\Delta d}{v}$

$\Delta t = \frac{150\ m}{0.77\ m/s}$

$\Delta t = 194.805194\ s$

$\Delta t \approx 190\ s$

8) In 1980, during the Marathon of Hope, Terry Fox ran 24 km [W] a day/ Assuming he ran for 8.0 h a day, what was his average velocity in m/s? ~~[1.5 m/s [W]]~~

$\Delta \vec{d} = 24\ km\ [W] = -24\ km = -24\ 000\ m$

$\Delta t = 8.0\ h = 28800$

$\Delta \vec{v} = ?$

$\Delta \vec{v} = \frac{\Delta \vec{d}}{\Delta t}$

$\Delta \vec{v} = \frac{-24000\ m}{28800\ s}$

$\Delta \vec{v} \approx -0.83\ m/s$

$\Delta \vec{v} = 0.83\ m/s\ [W]$

9) Calculate the magnitude of a bullet's acceleration if it travels at a speed of 1200 m/s and stops within a bulletproof vest that is 1.0 cm thick. [$7.2 \times 10^7\ m/s^2$]

$\vec{v}_1 = 1200\ m/s$

$\vec{v}_2 = 0\ m/s$

$\Delta \vec{d} = 1.0\ cm = 0.010\ m$

$\vec{a} = ?$

$\vec{v}_2^{\,2} = \vec{v}_1^{\,2} + 2\vec{a}\Delta \vec{d}$

$\vec{v}_2^{\,2} - \vec{v}_1^{\,2} = 2\vec{a}\Delta \vec{d}$

$\frac{\vec{v}_2^{\,2} - \vec{v}_1^{\,2}}{2\Delta \vec{d}} = \vec{a}$

$\vec{a} = \frac{(0\ m/s)^2 - (1200\ m/s)^2}{2(0.010\ m)}$

$\vec{a} = -7.2 \times 10^7\ m/s^2$

$a = 7.2 \times 10^7\ m/s^2$

10) A motorcycle coasts downhill from rest with a constant acceleration. If the motorcycle moves 90.0 m in 8.00 s, find its acceleration and velocity after 8.00 s. [22.5 m/s [downhill], 2.81 m/s^2 [downhill]]

$\vec{V_1} = 0\,m/s$

$\Delta t = 8.00s$

$\Delta \vec{d} = 90.0m$ [downhill]

$\Delta \vec{a} = ?$

$\vec{V_2} = ?$

acceleration

$\Delta \vec{d} = \vec{V_1}\Delta t + \frac{1}{2}\vec{a}(\Delta t^2)$

$2\Delta \vec{d} = \vec{a}(\Delta t)^2$

$\frac{2\Delta \vec{d}}{(\Delta t)^2} = \vec{a}$

$\vec{a} = \frac{2(90.0m)}{(8.00s)^2}$

$\vec{a} \simeq 2.81\,m/s^2$ [downhill]

$\vec{V_2}$

$\Delta \vec{d} = \frac{1}{2}(\vec{V_2} + \vec{V_1})\Delta t$

$2\Delta \vec{d} = \vec{V_2}\Delta t$

$\frac{2\Delta \vec{d}}{\Delta t} = \vec{V_2}$

$\vec{V_2} = \frac{2(90.0m)}{8.00s}$

$\vec{V_2} \approx 22.5\,m/s$ [downhill]

11) A cyclist crosses a 30.0 m bridge in 4.00 s. If her initial velocity was 5.00 m/s [N], find her acceleration and velocity at the other end of the bridge. [1.25 m/s^2 [N], 10 m/s [N]]

$\Delta \vec{d} = 30.0m$

$\vec{V_1} = 5.00m/s$

$\Delta t = 4.00s$

$\vec{a} = ?$

$\vec{V_2} = ?$

acceleration

$\Delta \vec{d} = \vec{V_1}\Delta t + \frac{1}{2}\vec{a}(\Delta t)^2$

$\Delta \vec{d} - \vec{V_1}\Delta t = \frac{1}{2}\vec{a}(\Delta t)^2$

$\frac{2(\Delta d - V_1\Delta t)}{(\Delta t)^2} = \vec{a}$

$\vec{a} = \frac{2(30.0m - 5.00m/s(4.00s))}{(4.00s)^2}$

$\vec{a} = 1.25\,m/s^2$

$\vec{a} = 1.25\,m/s^2$ [N]

$\vec{V_2}$

$\Delta \vec{d} = \frac{1}{2}(\vec{V_2} + \vec{V_1})\Delta t$

$\frac{2\Delta \vec{d}}{\Delta t} = \vec{V_2} + \vec{V_1}$

$\frac{2\Delta \vec{d}}{\Delta t} - \vec{V_1} = \vec{V_2}$

$\vec{V_2} = \frac{2(30.0m)}{4.00s} - 5.00m/s$

$\vec{V_2} = 10.0\,m/s$

$\vec{V_2} = 10.0\,m/s$ [N]

12) A car travelling at 19.4 m/s passes a police car at rest. As it passes, the police car starts up, accelerating with a magnitude of 3.20 m/s^2. Maintaining that acceleration, how long will it take the police car to catch up with the speeding motorist? At what speed would the police car be moving? Explain whether or not this scenario is likely to happen. [12.1 s, 39 m/s]

$\vec{V}_c = 19.4\,m/s$

$\vec{V}_{P1} = 0\,m/s$

$\vec{a}_p = 3.20\,m/s^2$

$\Delta t = ?$

$\vec{\Delta d}_c = \vec{\Delta d}_p$

$\vec{\Delta d}_c = \vec{V}_c \Delta t$

$\vec{\Delta d}_p = \cancel{\vec{V}_{p1}}^{0}\Delta t + \frac{1}{2}\vec{a}_p(\Delta t)^2$

$\vec{\Delta d}_p = \frac{1}{2}\vec{a}_p(\Delta t)^2$

When police car catches the speeder, their displacements would be equal.

$\therefore \vec{\Delta d}_c = \vec{\Delta d}_p$

$\vec{V}_c \Delta t = \frac{1}{2}\vec{a}_p(\Delta t)^2$

$\vec{V}_c \Delta t - \frac{1}{2}\vec{a}_p(\Delta t)^2 = 0$

$\Delta t\,(\vec{V}_c - \frac{1}{2}\vec{a}_p \Delta t = 0$

$\therefore \Delta t = 0$ or $\vec{V}_c - \frac{1}{2}\vec{a}_p\Delta t = 0$

Don't use for our case.

$\vec{V}_c = \frac{1}{2}\vec{a}_p\Delta t$

$2\vec{V}_c = \vec{a}_p\Delta t$

$\frac{2\vec{V}_c}{\vec{a}_p} = \Delta t$

$\Delta t = \frac{2(19.4\,m/s)}{3.20\,m/s^2}$

$\boxed{\Delta t \approx 12.1\,s}$

$\vec{V}_2 = \vec{V}_1 + \vec{a}\Delta t$

$\vec{V}_2 = 0\,m/s + 3.20\,m/s^2(12.1\,s)$

$\boxed{\vec{V}_2 \approx 38.7\,m/s}$

★ This scenario could happen on a highway, but not in a city.